Preliminary Bedrock Geologic Map and Cross Sections of the Windy Hill 7 ½' Quadrangle, Gila County, Arizona

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Scale 1:24,000; one sheet, no text

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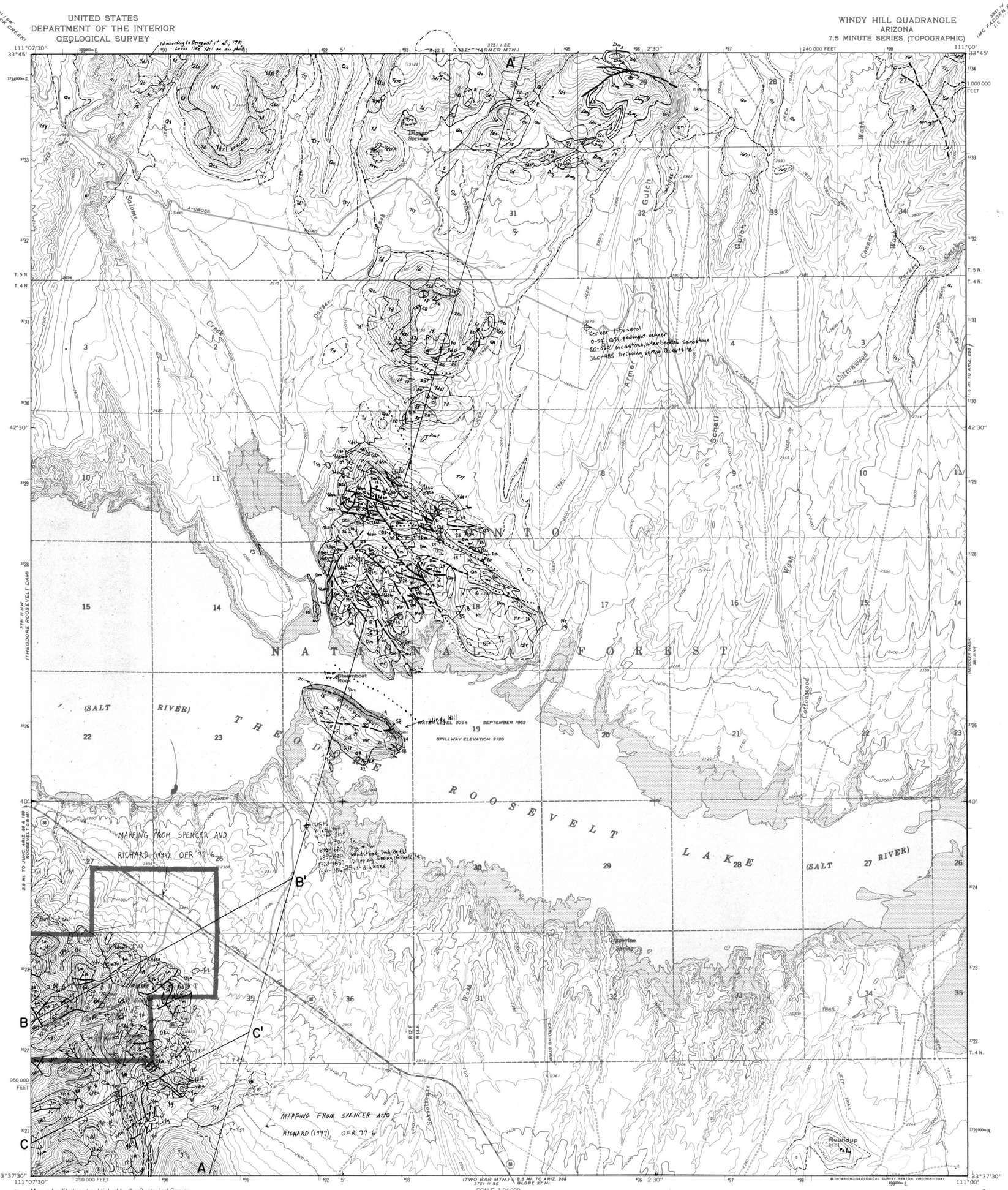

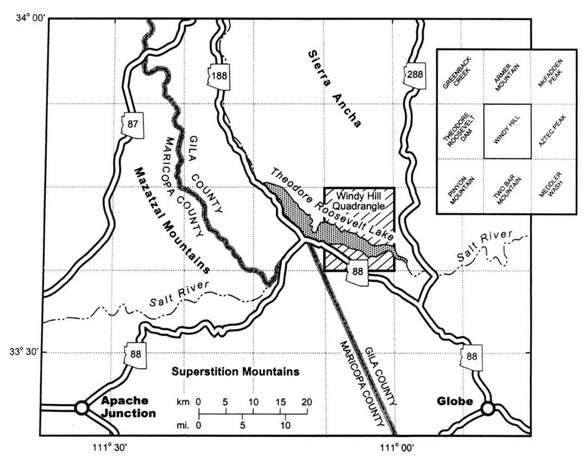

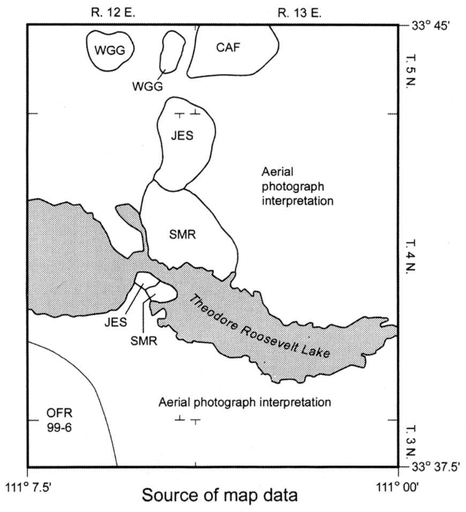

Map Symbols

- Drill hole

UNIT IDENTIFICATION

- Leader connecting areas of identical map unit
- Barnes Conglomerate at base of Dripping Spring Quartzite

CONTACTS (dashed where approximately located, dotted where concealed)

- Intrusive or depositional contact
- High-angle fault, showing dip, ball on downthrown side

ATTITUDES (orientation of planar and linear features)

Bedding:

- Upright
- Horizontal
- Approximate (upright)
- Apparent dip

Introduction

The Windy Hill 7 ½' Quadrangle is located in the southeastern part of Tonto Basin and includes bedrock on both sides of the basin. Bedrock geology is dominated by the middle Proterozoic Apache Group, the middle Proterozoic diabase that commonly intrudes it (e.g. Bergquist et al., 1981; Wrucke, 1989), and by overlying lower Paleozoic sandstone and carbonate rocks. Tertiary conglomerate and sandstone are deposited on the bedrock and are not greatly tilted or faulted. Upper Cenozoic sedimentary units and geomorphic surfaces were not mapped in most areas for this study because they have been mapped previously (Anderson et al., 1987). Bedrock in the southwestern corner of the quadrangle was mapped earlier by Spencer and Richard (1999) and their mapping is only partially represented in this report.

Cross Section of the Windy Hill Quadrangle (by S.M. Richard)

Cross section A-A' is contiguous northward with cross section A-A' of Bergquist et al. (1981). Apache Group strata in the southern Sierra Ancha (southwest of the Armer Mountain fault [Bergquist et al., 1981]) are horizontal to very gently southeast-dipping. At the edge of the range, which is the north end of our cross section A-A', the dip increases to about 15° to the southwest. This southwest dip characterizes strata southward along the section line to Windy Hill on the south side of Theodore Roosevelt Lake. Numerous faults cut the section, primarily with down to the northeast separation. The slip on these faults is not well constrained. Based on the outcrop trace of the faults and rare exposures, faults appear to dip steeply to vertical. The strike of the faults is oblique to the strike of bedding in Apache group and lower Paleozoic strata. This geometry suggests that the faults may be strongly oblique slip, or normal faults that cut previously tilted strata.

The U.S. Forest Service Windy Hill water test well is located about 4000' south of Windy Hill. This well penetrated about 1640' of basin fill, about 45' of carbonate rock (either Martin Formation or dolomite of the Mescal "Limestone"), 35' of sandstone that could be lower Martin Formation or Bolsa Quartzite, 130' of probable Dripping Spring Quartzite, and bottomed in diabase (Richard, 1999). The dip of the penetrated strata is unknown, but extrapolation of the top of the Dripping Spring Quartzite from its projected position beneath Windy Hill requires either a down to the southeast fault between Windy Hill and the well, or that the southwestward dip of the strata increases towards the well. On Windy Hill itself, the dips decrease southwestward and up section; thus a fault has been interpreted between Windy Hill and the well.

Before discussing the southern end of section A-A', it is necessary to study sections B-B' and C-C'. Apache Group and Paleozoic strata at the northeast end of Two Bar Ridge (southwestern corner of Windy Hill quadrangle) dip gently to moderately in an easterly direction, and a series of mostly northwest-trending faults with down-to-the-northeast separation cut strata in this area (Spencer and Richard, 1999). Section B-B' includes the northeastern end of section B-B' from Spencer and Richard (1999), and extends this section northeastward to meet section A-A' of this report at a point 1200 feet south of the USFS Windy Hill water test well. A range-front fault with a separation of about 2000 feet is inferred in this section to displace the top of the Dripping Spring Quartzite down to an elevation comparable to its elevation in the Windy Hill test well.

Section C-C' is drawn to highlight the structural complexity at the northern end of a major north-trending fault that cuts the eastern side of Two Bar Ridge (Spencer and Richard, 1999). This fault has been mapped southward for about 6 km, where it is overlapped by Tertiary conglomerate of uncertain exact age (Peterson and Jinks, 1983). The fault juxtaposes Proterozoic Ruin(?) granite against rocks of the Apache Group with a down-to-the-west separation. At its northern tip, the fault intersects, and is apparently truncated by a northwest-trending fault that has down-to-the-northeast separation. Highly faulted Mescal Limestone and overlying Proterozoic basalt are continuous around the intersection of these two faults (Spencer and Richard, 1999). The north-trending fault is apparently dragged to the southeast (right-lateral sense) along the northwest-trending fault. The complex pattern of faulting in Apache Group strata in the southwest corner is interpreted as an intersection zone between coeval northerly-trending faults that bound the eastern side of Two Bar Ridge, and northwest-trending faults that form the southwest margin of the Tonto Basin to the northwest. Alternating movement on faults with different orientation, and large displacement changes over short distances, may be due to slip transfer between the fault systems. Extrapolation of this structure into the subsurface beneath the basin fill not feasible, so the northeastern part of section C-C' has been interpreted as a simple northeast-dipping homocline, continuing the dip of strata at the edge of the range with offset by a range-bounding normal fault. Normal separation on the range-bounding normal fault is not constrained by data. The existence of Martin Formation and Redwall Limestone in the subsurface here is purely speculative.

The southern end of section A-A' is shown as a broad synform between the southwest-dipping strata between Windy Hill and the Sierra Ancha and the easterly-dipping strata of Two Bar Ridge. The geometry of the structure beneath the basin is poorly constrained, but any geometric interpretation must explain the reversal of regional dip between Two Bar Ridge and Windy Hill. Plausible interpretations of this structure include the following: (1) It may be a synform related to formation of the Tonto Basin in Miocene time, (2) the east-tilted strata of Two Bar Ridge may be a southern continuation of the east-tilted Mazatzal Mountains, with both in the hanging wall of a late Cenozoic, west-dipping, moderate to low-angle normal fault (Ferguson et al, 1998), (3) the structure may represent a Laramide monocline modified by Tertiary normal faults that have tilted the strata to the southwest. The east-tilted strata along Two Bar Ridge and north of Theodore Roosevelt Dam (Spencer and Richard, 1999) would have been the more steeply east-tilted eastern side of a Laramide 'Mazatzal uplift' that was a source for the Eocene Mogollon Rim Formation (Potochnik, 1989; Potochnik and Faulds, 1998). Southwestward tilting in Miocene time would have decreased the dip of these strata after tilting related to monocline formation. At present there are insufficient data to rule out any of these hypotheses.

Map Units

Qs **Surficial deposits, undivided (Quaternary)**—Undivided alluvium, talus, colluvium, and local active channel deposits. Typically consists of weakly to moderately indurated gravel and sand. Primarily exposed on weathered, slightly to moderately incised alluvial fans and alluvial valley filling deposits that form gentle to moderate slopes adjacent to hills and mountains. Also includes alluvium in recently active channels and some colluvium and talus.

Qtc **Talus and colluvium (Quaternary)**—Weakly to non-indurated deposits mantling hill slopes on bedrock. Typically consists of angular clasts of locally derived rock in a sand and clay matrix, derived by weathering of bedrock and downslope movement of regolith material. Mapped where hill-slope deposits are thick enough to obscure the nature of the underlying bedrock. Non-conformably overlies all older deposits. Locally includes deposits with boulders >1 m diameter.

Qo **Old Alluvium (Quaternary)**—Cobble and boulder alluvium in topographically high areas on bedrock or forming broad areas deeply incised by drainages.

QTs **Poorly sorted sand and gravel deposits (Pleistocene to Pliocene)**—Unconsolidated, poorly sorted sand and gravel deposits of uncertain age and stratigraphic position relative to other upper Cenozoic deposits.

QTr **Old major river deposits (Pliocene to middle Pleistocene)**—Thin deposits of gravel consisting of sub-rounded to well-rounded pebbles and cobbles of Paleozoic carbonates and quartzites, Apache Group strata, diabase, and Proterozoic granite, metavolcanic rocks, and quartzite. Overlies older units on erosional unconformity.

Tsy **Siltstone, sandstone and sparse conglomerate (Pliocene)**—Very light gray, laminated to very thin-bedded, fine to medium-grained, lithic sandstone and siltstone. Interbedded with cobble to boulder conglomerate containing rounded clasts of Apache group and diabase, especially near basin margins or bedrock exposures.

Tsyc **Conglomerate (Miocene or Pliocene)**—Basin margin facies of map unit Tsy.

Mr **Redwall Limestone (Mississippian)**—Gray crystalline limestone, fine-grained to medium grained. Relict crinoid columnals are commonly present, and some limestone beds appear to have been crinoid grainstone. Typically thick bedded, with some medium-bedded intervals. An interval that contains abundant horn-coral fossils is present about 20 m above the base of the unit. Some limestone beds near the base contain sparse spherical quartz grains. In one location about 1 m of terra rossa was observed at the Martin-Redwall contact. Otherwise the contact is sharp and unremarkable. Upper contact of Redwall is erosional unconformity overlain by Tertiary sedimentary rocks.

Dm **Martin Formation (Devonian)**—Stratigraphy of Martin Formations is variable in detail. Teichert (1965) divided the Martin Formation into the lower Beckers Butte Member and the upper Jerome Member, but these divisions were not used because sandstone characteristic of the Beckers Butte Member is present at many levels in the Martin Formation and is not particular conspicuous at the base. The base is typically a 0.5 m bed of dolomitic sandstone, with prominent brown sandstone laminations that weather in relief. Sand consists of about 99% fine-grained sub-rounded quartz, with a trace of medium- to coarse-grained, well rounded to spherical quartz grains. In some places a thin basal conglomerate is present that contains 1-3 cm diameter, angular clasts of upper Dripping Spring Quartzite or Mescal chert. This basal unit is overlain by 0-5 m of light buff-gray, slightly sandy dolomite or gray, platy-weathering laminated dolomite overlain by a prominent 2-5 m-thick interval of very light gray to white porcelaneous, slightly sandy, thin-bedded dolomite. Where the underlying Mescal Limestone is thickest, the porcelaneous dolomite unit is directly on the unconformity; where more Mescal has been eroded, there is more Martin section beneath the porcelaneous dolomite. Above the porcelaneous dolomite, the stratigraphy was not studied in sufficient detail to discern local variations, but several prominent marker horizons appear to be consistent throughout the area. The next marker horizon is 5-10 m above the porcelaneous dolomite, and is a light gray, vitreous quartzite to friable quartz arenite that contains rare glauconite grains, and 10-20 cm amplitude, trough cross beds. Quartz grains in this unit are up to 2 mm diameter, and the sand is very poorly sorted. Above this is 20-30 m of tan sandy dolomite in thin to medium beds, with marly intervals. Sparse fenestrate bryozoan, crinoid columnals, and brachiopods are present, particularly in the marly intervals. A few very thin brachiopod packstone beds are present. The interbedded marl-dolomite interval is overlain by an upper sandstone unit 10-15 m thick that strongly resembles the quartzite-sandstone unit beneath the marl-dolomite interval. At the base of this upper sandstone, zones of convoluted bedding and dish structure are present in some areas; 1-cm-amplitude herringbone cross-laminated beds are also present in this interval. The top of the Martin Formation consists of 10-15 m of thick, cherty dolomite beds. Chert forms irregular globs and coalesced nodules; bedding is poorly defined.

Lower contact is erosional unconformity on upper Dripping Spring Quartzite, Mescal Limestone, or diabase. At one location (SW¼, sec. 6, T. 4 N., R. 13 E.), basal sandstone that may correlate with the Beckers Butte member of the Martin Formation consists of poorly sorted, quartz-rich sandstone with local rip-ups of fine grained sandstone up to 10 cm long. Cross beds are 5 to 20 cm thick. Both cross beds and plane beds have opaque-rich layers; opaque mineral is probably magnetite derived from middle Proterozoic diabase. Sandstone is not brown in color as is common in some areas of suspected Cambrian Bolsa Quartzite that contain much iron-rich debris derived from the diabase.

This map unit was locally divided into lower, middle, and upper members (Dm_1, Dm_2, and Dm_3) near the north edge of the map area.

The upper contact with Redwall Limestone is a disconformity. It is placed at the transition from thick beds of cherty dolomite to thick beds of recrystallized limestone. The contact can be difficult to spot from a distance, but on close inspection can generally be located quite closely.

Yd **Diabase (Middle Proterozoic)**—Dark gray, dark greenish gray, and grayish black sills and dikes with typical sub-ophitic, diabasic texture.

Ym **Mescal Limestone (Middle Proterozoic)**—Incomplete section preserved beneath erosion surface at base of Martin Formation. At base is 1-2 m thick bed of red brown to orange, variably silicified, calcareous quartz arenite that overlies the 0.5 m vitreous quartzite marker used as the top of the Dripping Spring Quartzite. The vitreous quartzite forms prominent float even on slopes with very poor exposure. This is overlain by about 10 m of non-resistant orange to brown marl, argillite, calcareous or dolomitic fine-grained sandstone, and possible sedimentary (solution collapse?) breccia. This interval is non-resistant and typically forms a slope. Gray chert fragments are common in the float. Above this are cherty dolomite beds. These are 0.5 to 1.5 m thick, with rough, irregular weathering, and gray to tan color; chert nodules form irregular globs. At the upper contact this rock becomes darker colored in some areas, probably due to pre-Martin weathering. Conformably overlies Dripping Spring Quartzite. Overlain by Martin Formation on erosional unconformity.

Yb **Basalt (Middle Proterozoic)**—Exposed only in the southwestern corner of the map area. Description modified from Spencer and Richard (1999) is as follows: Dark gray to black basalt lava flows and flow breccias that are part of the Apache Group.

Yds **Dripping Spring Quartzite, undivided (Middle Proterozoic)**

Ydsu **Upper unit**—Thin- to very thin-bedded, very fine to fine-grained quartzite or feldspathic quartzite. Weathered surfaces are gray, brown or orangish gray. A 0.5-m-thick, white, vitreous, quartzite marker bed is mapped as the top of the unit. Lower contact with lower Dripping Spring Quartzite is mapped in only one location, and is very poorly exposed. Float mapping indicates that some shale and white, laminated, very fine-grained sandstone is present in the lower part of this unit. This would correlate with strata mapped as middle Dripping Spring Quartzite in the Theodore Roosevelt Dam quadrangle (Spencer and Richard, 1999), but has not been differentiated on this map. Upper contact with Mescal 'Limestone' is concordant, apparently conformable, and marked by a white, vitreous quartzite marker bed. Lower contact placed at top of medium-bedded quartzite of lower Dripping Spring Quartzite.

Ydsm **Middle unit**—Exposed only in the southwestern corner of the map area. Description modified from Spencer and Richard (1999) is as follows: Maroonish brown to light gray siltstone to shale and very fine grained, silty sandstone that forms gentle slopes or, most commonly, is buried by talus and colluvium. Scattered quartzite beds form subtle to prominent ledges.

Ydsl **Lower unit**—Medium- to thick bedded, light tan or orange quartzite, feldspathic quartzite and arkose. Basal Barnes conglomerate contains moderately well rounded cobbles and pebbles of chert and quartzite, but the depositional base of the unit is intruded by diabase and the depositional contact at the base of the Barnes conglomerate is not exposed. Upper contact with upper Dripping Spring Quartzite placed at top of resistant, medium-bedded quartzite.

Yp **Pioneer Formation (Middle Proterozoic)**—Exposed only in the southwestern corner of the map area. Description modified from Spencer and Richard (1999) is as follows: Maroon, maroonish gray, tan, and brown psammite, silty psammite, and sandy phyllite, commonly with a basal conglomerate.

Yg **Coarse-grained, porphyritic biotite granite (Middle Proterozoic)**—Exposed only in the southwestern corner of the map area. Description modified from Spencer and Richard (1999) is as follows: Coarse-grained biotite granite with sparse, 5-15 cm mafic enclaves. K-feldspar phenocrysts up to 4 cm diameter poikilitically enclose sparse, 1-2 mm plagioclase and biotite. The granite consists of 15-25% K-feldspar, both as phenocrysts and 1-6 mm diameter anhedral grains, 5-10% biotite in 1-3 mm-diameter flakes, 25-30% quartz in aggregates of 1-2 mm-diameter grains that are up to 6 mm in diameter, and 35-45% plagioclase in subhedral grains 2-5 mm in diameter.

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